

sponge under all circumstances. How long these canals may be, whether they perforate the thin wall of an *Olynthus* as simple apertures, or in other forms traverse the thick body-wall as a system of profusely branched and frequently anastomosing passages, is quite irrelevant, and depends solely upon the degree of development of the mesoderm. It might perhaps still be objected that the canal-system of the Sponges is developed in such different ways that it certainly cannot always take its origin from the primitive gastral cavity, but at least as often be formed by gaps which make their appearance in the mesoderm, and growing on centripetally and centrifugally, perforate the gastral and dermal surfaces of the sponge-wall only in the second line. But we must not overlook one thing: how is the gastrula of the sponge formed? In perfectly analogous ways: some by invagination, and with this process the formation of the gastral canals from the stomach outwards may be compared; the others by the appearance first of all of a cavity in the cœnoblastema and its subsequent breaking through outwards; and this may be placed side by side with the origination of the canal-system from gaps occurring in the mesoderm. I believe that the former process, as well as the formation of the gastrula by invagination, is the older and more typical, and that the second must be accounted for by some phenomena of adaptation *sui generis*.

In conclusion, I must again assert that it seems to me, so far as the conditions are at present before us, that the arguments which have been urged against the Cœlenterate nature of the Sponges are far from counterbalancing those which are in favour of it.

XII.—*On some Points in the Morphology of the Echinoderms, and more especially of the Crinoids.* By P. HERBERT CARPENTER, D.Sc., F.R.S., Assistant Master at Eton College.

IN a recent number of the 'Revue Scientifique'*, Professor Edmond Perrier has published a short and semipopular article, the title of which appears in the table of contents as "Les Encrines Vivantes, d'après les Explorations du *Challenger*." The author's treatment of his subject, however, is not altogether in accordance with the expectations to which such a title gives rise; for his article is headed simply "Les encrines vivantes," and of the six columns to which it

* *Revue Scientifique*, tome 35, No. 22, 30 Mai, 1885, pp. 690-693.

extends, not more than half of one and one third of another are concerned with a notice of the Report* on the Stalked Crinoids dredged by the 'Challenger' and the 'Blake.' The remainder of the article is almost entirely devoted to (1) an exposition of the views which Prof. Perrier holds respecting the circulatory apparatus of the Echinoderms in general and of the Crinoids in particular; (2) a new primary classification of the Metazoa; (3) a list of the genera of recent "Encrines"; and (4) a list of the species in the Paris Museum of Natural History.

I propose to say a few words upon each of these heads, with the exception of the second, to which I would direct the attention of those zoologists who are interested in questions of general classification.

Prof. Perrier regrets that with the material at my disposal I did not enter more fully into "une histoire anatomique des Encrines vivantes" †. At the commencement of chapter vi. of the 'Challenger' Report, which contains 42 pages devoted to the minute anatomy of the disc and arms, I stated expressly that I did not propose to devote so much attention to this subject as I had done to the comparative morphology of the Crinoid skeleton; for I had been "able to confirm, in almost every respect, the admirable investigations of Ludwig ‡ on the minute anatomy of *Antedon rosacea*." It did not appear to me to be necessary to go into the whole question again from the beginning, and I therefore limited myself to a general account of the anatomy of the soft parts as far as I have been able to work it out in six genera of Stalked Crinoids and in three *Comatulæ*. In addition to this, I entered into a considerable amount of anatomical detail when discussing the generic affinities of *Rhizocrinus* and *Bathycrinus*. But, unfortunately, Professor Perrier tells us that many of Ludwig's results, and therefore, by implication, of mine too, are erroneous. This is doubtless only too true, and I am anxiously awaiting Prof. Perrier's promised demonstration of the fact.

Owing to the circumstances of the case, the material at my disposal had not been specially prepared for minute anatomical work, having been in spirit for many years without any previous hardening; while, on the other hand, Prof. Perrier's observations have been carried out on a constant supply of fresh material with all the advantages of an elaborate

* Zool. Chall. Exp. part xxxii.

† *Loc. cit.* p. 693.

‡ "Beiträge zur Anatomie der Crinoideen," Zeitschr. f. wiss. Zool. 1877, Band xxviii. pp. 255-353, Taf. xii.-xix.

technique. Under these circumstances he has certainly seen much which had escaped my notice. But this scarcely justifies him in saying "Toute la physiologie des crinoïdes demeure donc, après le travail du naturaliste du *Challenger*, dans l'obscurité où il l'avait trouvée"*. I freely admit that I have not yet risen to the conception that the water which enters the body-cavity of a Crinoid by the ciliated funnels of the disc is expelled by powerful muscles through pores at the syzygies of the skeleton; nor that the blood- and water-vessels of a Crinoid, together with the body-cavity and its radiating extensions, constitute a vast system of intercommunicating canals with "le même rôle physiologique que l'ensemble des cavités creusées dans le corps des polypes et des éponges" †.

It is difficult to study pure physiology upon spirit specimens, and it is unfortunately true that I have been unable to add much to Ludwig's account of the circulatory apparatus; but, all the same, I venture to think that I have made some additions to our knowledge of the physiological anatomy of the Crinoids. I speak under correction; but it is certainly my impression that the Report on the 'Challenger' Crinoids, together with my previous writings upon the subject, contains the first descriptions and figures of the following points of physiological anatomy:—

1. The trifascial articulation between certain joints of the rays and arms of *Bathycrinus*, and the entire absence of syzygies in this genus.

2. The complex coiling of the alimentary canal in *Actinometra*, and the accompanying variation in the structure of its ovoid gland, to use Perrier's own expression.

3. The presence at the sides of the ambulacra, both of disc and arms, of radiating branches from the axial nerves of the skeleton; and the extension of fibres from this network into the spinelets on the disc of *Pentacrinus*.

4. The ramification within the stem-segments of fibres from their central nervous axis.

5. The absence of any ambulacral grooves and of their associated organs on the arms and disc in many specimens of *Actinometra*, and on the completely plated genital pinnules of some species of *Antedon*.

6. The presence of well-developed ovaries in the disc of individuals of two species of *Antedon* and one of *Actinometra* †.

* *Loc. cit.* p. 693.

† *Ibid.* p. 692.

‡ Professor Perrier intimates that I differ from my father with respect to that portion of the genital glands which lies within the disc of a

The above list might be considerably extended. I trust, however, that it is long enough to show that the Crinoid collections made by the 'Challenger' and 'Blake' have not been so completely barren of additions to our physiological knowledge as Professor Perrier asserts.

But the absence of physiological results has not been my only sin of omission. According to Professor Perrier, I ought to have worked out in detail the embryogeny of the common *Antedon rosaceus* of the British seas, for the purpose of throwing light upon the anatomy of the adult Crinoid; and he says that I might have obtained the necessary materials at Eton, since he procured them at Paris*. Has he forgotten the note † which I sent him last year "On some Points in the Anatomy of larval Comatulæ"? I stated in this note that I had continually felt the want of some knowledge of the organogeny of the Crinoid type, and had therefore procured larvæ of various stages from Naples and Torquay, which had enabled me to check some of the results obtained from an investigation of the adult anatomy. But as I was not professing to write an exhaustive monograph of the Crinoidea, I did not conceive it to be part of my duty to work out a detailed account of the embryogeny of a type which is accessible to every European naturalist. An already lengthy report would have been swelled to gigantic dimensions. The number of plates required would have increased from 69 (not 61, as quoted by Perrier) to over 100, for Prof. Perrier tells us that his own memoir on this subject is still incomplete, and that thirty plates are already drawn. If the various naturalists who have undertaken to report upon the different groups of animals collected by the 'Challenger' were expected to give a complete anatomical and physiological description of each group, and to supplement it by a detailed account of the embryogeny of its representative in European seas, the publication of their reports would be delayed indefinitely; and yet

Crinoid. I can only say that I cannot understand how this impression can have occurred to any one who has taken the trouble to read pp. 108 and 109 of the 'Challenger' Report.

* I would here express my sense of the courteous kindness of Prof. H. de Lacaze-Duthiers, who offered to place at my disposal all the resources of his laboratory at Roscoff, during June and July of this year, for the purpose of working out the embryogeny of *Antedon rosaceus* by the most approved modern methods. I would have given much to have been free to accept this invitation; but my professional duties kept me in England during both the months named, and, for the present at least, I must leave the verification of Prof. Perrier's results to other hands.

† Quart. Journ. Micr. Sci. N.S. vol. xxiv. pp. 319-327 (April 1884).

this appears to be the standard set up by Professor Perrier for those who have large zoological collections committed to their charge for examination and description within a limited time.

Under these circumstances, therefore, one might expect that the Report by Professor Perrier* upon the fifty-four species of Asterids which were obtained by the 'Blake' in the Caribbean Sea, a collection second only in importance to that made by the 'Challenger,' would be a model of its kind.

In the absence both of an index and of a table of contents, one has some difficulty in making out what is contained in this memoir of 150 pages. Of the ten plates which accompany it, only one is devoted to any other part of the subject than the external appearance of the new species established by Prof. Perrier. At the foot of this plate, which is almost entirely occupied by figures of pedicellariæ and spines, there is the extraordinary legend "Organisation des *Hymens discus*"; and the reader has to turn back to the explanation of the plates in order to learn that the name of Prof. Perrier's new genus is in reality *Hymenodiscus*. Not one of the remaining nine plates contains any figures illustrating the organogeny of the starfish, a subject upon which we are still much in want of information, despite the admirable researches of Ludwig † upon *Asterina gibbosa*. Neither is there any section of the text devoted to this question, while the amount of physiological and anatomical information which the report contains is meagre in the extreme.

Three years ago Professor Perrier published a short note ‡ in the 'Comptes Rendus' to call in question the correctness of some of Ludwig's observations on Asterid morphology; and many Echinoderm students had hoped that he would take the opportunity afforded by the material of the 'Blake' Starfishes to substantiate his charges respecting the accuracy of Ludwig's work on the group. But the whole question is completely ignored, with the exception of one or two references to the position of the stone-canal, and there is not a word about the organogeny of the Starfish type, a subject which, according to

* "Mémoire sur les Etoiles de Mer recueillies dans la Mer des Antilles et le Golfe du Mexique durant les Expéditions de dragage faites sous la direction de M. Alexandre Agassiz," Nouvelles Archives du Muséum d'Histoire Naturelle, 2^e série, tome vi. 1884, pp. 127-276, pls. 1-10 (1884).

† "Entwicklungsgeschichte der *Asterina gibbosa*, Forbes," Zeitschr. f. wiss. Zool. Bd. xxxvii. 1882, pp. 1-98, Taf. i.-viii.

‡ Perrier and Poirier, "Sur l'Appareil circulatoire des Etoiles de Mer," Comptes Rendus, t. xciv. 1882, pp. 658-660.

Prof. Perrier's standard for other reports, should have been worked out in full detail.

His own report commences with a section upon the primary divisions of the class of Stellerids, the keynote of which is struck in the following sentence * :—" On peut dire d'une manière générale que toutes les Etoiles de mer à tubes ambulacraires bisériés, ont une bouche ambulacraire, et que toutes les Etoiles de mer à tubes ambulacraires quadrisériés, au moins à la base des bras, ont une bouche ambulacraire."

The unfortunate zoologist who is not a Starfish specialist, but merely wishes to learn the general systematic results which have been arrived at by the most eminent living writer on the group, will rise from the perusal of this sentence with an even more confused notion of the classification of the Asterids than he had before. For, according to Viguier †, the biserial ambulacra are usually, but not always, correlated with an adambulacral mouth, and not with an ambulacral one as Professor Perrier tells us.

Two pages further on he commences another section which is devoted to the morphological signification of the pedicellariæ in Asterids and Urchins and to their physiological rôle. But no reference whatever is made to the elaborate observations of Romanes and Ewart ‡ upon the functions of the pedicellariæ; and the discovery of glands upon the gemmiform pedicellariæ of Echini is attributed to Geddes and Beddard, although these authors themselves admit § that their "account of the structure of these pedicellariæ substantially bears out what has been said" by Sladen ||. But although Mr. Sladen's paper was published in 1880 it is completely ignored by Prof. Perrier four years later; and Foettinger's memoir ¶ on the same subject is also left entirely without notice. The same neglect of the writings of the English naturalist who is engaged in working out the 'Challenger'

* *Op. cit.* p. 138.

† "Anatomie comparée du squelette des Stellérides," Arch. de Zool. expér. et gén. t. vii. Année 1878, p. 82.

‡ "Observations on the Locomotor System of Echinodermata," Phil. Trans. 1881, pp. 840-852.

§ "On the Histology of the Pedicellariæ, and the Muscles of *Echinus sphæra*," Trans. Roy. Soc. Ed. vol. xx. 1881, p. 392.

|| "On a remarkable Form of Pedicellaria and the Functions performed thereby; together with General Observations on the Allied Forms of this Organ in the Echinidæ," Ann. & Mag. Nat. Hist. ser. 5, vol. vi. Aug. 1880, pp. 101-114, pls. xii., xiii.

¶ "Sur la Structure des Pédicellaires gemmiformes de *Sphærechinus granularis* et d'autres Échinides," Arch. de Biol. vol. ii. pp. 455-496, pls. xxvi.-xxviii.

Starfishes appears in the systematic portion of Prof. Perrier's report.

In the year 1882, Sladen published an account of the structural peculiarities presented by the Pterasteridæ, and pointed out their systematic value *; but although Prof. Perrier enters into some detail respecting the structure of *Pteraster caribbæus*, he completely ignores all that had been written upon the subject two years previously.

In fact, throughout the whole of Prof. Perrier's report the work of German and English writers upon the morphology of the Asterids, and their relation to the Echinodermata generally, is left entirely unnoticed. The observations of Geddes and Beddard were made in a French laboratory and are therefore mentioned; but no reference is given to the place of their publication; while the papers of Ludwig, Sladen, and myself might never have been written so far as Prof. Perrier is concerned. This neglect of the results of fellow workers who do not happen to be Frenchmen may be patriotic, but it is neither wise nor scientific; and in one case, as has been already explained in this journal †, Prof. Perrier's omission to consult any one of some four papers by Pourtalès and myself which contain descriptions of the calyx of *Rhizocrinus* has led to zoological science being enriched with a new synonym. For Prof. Perrier has at last come to the conclusion, as he would have done at first had he taken the trouble to make himself acquainted with the literature of his subject, that his genus *Democrinus* is identical with *Rhizocrinus* ‡.

It was pointed out by Pourtalès in 1868 §, and again in 1874 ||, that *Rhizocrinus* has large and well-developed basal plates like those of *Bourgueticrinus*; and in his second paper he corrected the mistake which had been made by Sars ¶ in describing the basals of *Rhizocrinus* as internal and concealed. These results were confirmed by myself in 1877 **, and again

* "The Asteroidea of H.M.S. 'Challenger' Expedition.—Part I. Pterasteridæ," Journ. Linn. Soc., Zool. vol. xvi. pp. 190, 191.

† "Note on *Democrinus Parfaiti*," Ann. & Mag. Nat. Hist. ser. 5, vol. xi. pp. 334-336.

‡ Revue Scientifique, 30 May, 1885, p. 691, note.

§ "Contributions to the Fauna of the Gulf Stream at Great Depths," Bull. Mus. Comp. Zoöl. vol. i. no. 7, pp. 128-130.

|| "Zoological Results of the 'Hassler' Expedition," Ill. Cat. Mus. Comp. Zoöl. no. viii. pp. 28, 29.

¶ 'Mémoires pour servir à la connaissance des Crinoïdes vivants,' Christiania, 1868, p. 12.

** "On some Points in the Anatomy of *Pentacrinus* and *Rhizocrinus*," Journ. Anat. & Physiol. vol. xii. 1877, p. 50.

in 1882*. I know that Prof. Perrier received copies of both papers. In fact he quoted a portion of the second one (without acknowledgment) in his brief notice of *Democrinus* in the 'Comptes Rendus' †. Nevertheless he stated in this description that the basals of *Rhizocrinus* are "confondues," while those of *Democrinus* are large and well developed, this being the very character of *Rhizocrinus* which had been pointed out four times by Pourtalès and myself during the previous thirteen years.

A similar neglect of the work of other naturalists appears in that section of the report on the 'Blake' Starfishes which is devoted to the morphological signification of the odontophore. Page 159 of this section is disfigured by two serious errors. In one place we are told that "les pièces radiales" of the young Starfish become the odontophores of the adult; and, as if to impress the characteristic symmetry of the Echinoderm type still more forcibly upon the mind of the reader, the author continues "L'une de ces pièces radiales ne tarde pas à présenter les sillons caractéristiques de la plaque madreporique."

Much has been written by Ludwig ‡ about the morphology of the odontophore in the Asterids; but his name, like that of Sladen, is conspicuous by the absence of any reference to it in the memoir of Prof. Perrier. In fact, Ludwig's theory that the periproct of an urchin is represented, not by the calyx but by the ventral side of a Crinoid §, is put forward as a novelty by Prof. Perrier ||, who is apparently unaware that it was published by Ludwig so long ago as 1880, and that the morphological difficulties which it involves were pointed out by myself in the same year ¶. Even in those cases when Prof. Perrier is compelled to take account of the work of another author, he is often unable to quote correctly, and the results are sometimes remarkably confusing. After reproducing (with-

* "The Stalked Crinoids of the Caribbean Sea," Bull. Mus. Comp. Zoöl. vol. x. no. 4, 1882, p. 174.

† "Sur un nouveau Crinoïde fixé, le *Democrinus Parfaiti*, provenant des dragages du 'Travailleur,'" Comptes Rendus, tome xcvi. no. 7, pp. 450, 451.

‡ 'Morphologische Studien an Echinodermen,' Bd. i. Leipzig, 1877, pp. 228-234, 254-269; and also "Das Mundskelet der Asterien und Ophiuren," Zeitschr. f. wiss. Zool. Bd. xxxii. 1879, pp. 672-688.

§ *Ibid.* p. 688; and also "Ueber den primären Steinkanal der Crinoiden nebst vergleichend-anatomischen Bemerkungen über die Echinodermen überhaupt," *ibid.* Bd. xxxix. 1880, pp. 317-319.

|| *Op. cit.* p. 161.

¶ "Some disputed Points in Echinoderm Morphology," Quart. Journ. Microsc. Sci. vol. xx. new ser. pp. 322-329.

out acknowledgment) the list of families and genera of the living Stalked Crinoids described in the 'Challenger' Report, he adds*, "Oltre ces six genres, deux autres genres d'Encrines ont été décrits, le genre *Ilyocrinus* par Koren et Daniellsen (*sic*), et le genre *Democrinus* par moi. Les auteurs scandinaves s'accordent à penser que leur *Ilyocrinus* n'est qu'un *Bathycrinus alarchianus* mieux développé que le type. Je trouve cependant dans les collections du 'Talisman' un crinoïde d'assez grande taille, chez qui il existe cinq basales non soudées, presque aussi grande que les radiales; si cet exemplaire unique n'est pas une monstruosité, c'est un *Ilyocrinus* qu'on pourrait appeler *Ilyocrinus recuperatus*."

This paragraph contains two serious (clerical?) errors. The name of Daniellsen and Koren's genus is *Ilycrinus* †, not *Ilyocrinus*; and *Bathycrinus Aldrichianus* would be more correct than *Bathycrinus alarchianus*. It may be that Prof. Perrier has had some private communication with the Scandinavian authors upon the subject; but I have no knowledge of their having published any such views as he attributes to them. According to him they regard *Ilycrinus* (*Carpenteri*) as a *Bathycrinus Aldrichianus* better developed than the type. The type of what? of *Bathycrinus Aldrichianus*? This can hardly be the case, for the two species are very nearly the same in size, the 'Challenger' form from the southern seas being, if anything, slightly larger than *Bathycrinus Carpenteri* (*Ilycrinus*) from the North Atlantic.

Prof. Perrier's statement reads like a paraphrase of what I wrote respecting *Bathycrinus* and *Ilycrinus* in 1882. The former genus was founded upon an immature specimen dredged by the 'Porcupine,' which Sir Wyville Thomson named *Bathycrinus gracilis* ‡; and I pointed out § that "his description || of the larger species, *B. Aldrichianus*, from the southern sea, seems not to have reached the Norwegian naturalists before the publication of their genus *Ilycrinus*, which was founded on much more developed individuals than that dredged by the 'Porcupine.'" This *B. gracilis* appears to be the poorly developed type which is referred to by Prof. Perrier in this exposition of the views of Daniellsen and Koren, who have not, so far as I am aware, ever made any such

* 'Revue Scientifique,' May 30, 1885, p. 691, note.

† "Fra den Norske Nordhavsexpedition Echinodermer," *Nyt Mag. f. Naturvid.* Bd. xxiii. 1877, p. 45.

‡ "On the Crinoids of the 'Porcupine' Deep-sea Dredging Expedition," *Proc. Roy. Soc. Edinb.* vol. vii. 1869-72, p. 772.

§ *Bull. Mus. Comp. Zool.* vol. x. no. 4, p. 177.

|| "Notice of new Living Crinoids belonging to the Apicrinidæ," *Journ. Linn. Soc., Zool.* vol. xiii. 1876, pp. 48-51.

comparison between their *Ilycrinus* and *Bathycrinus Aldrichianus* as is attributed to them by Prof. Perrier.

He further mentions a remarkable specimen with five basals which are not united, and are almost as large as the radials. It cannot be *Ilycrinus* (D. & K.), which has quite small and very closely united basals; but if it is not a monstrosity, I am quite prepared to accept it as a new genus, *Ilyocrinus*, Perrier, with the specific name *recuperatus*. I must protest, however, against its appearing on the same page of Perrier's article among the list of Crinoids in the Paris Museum as *Hyocrinus recuperatus*. This is especially confusing, as there is already a well-known genus *Hyocrinus*, which was established by Sir Wyville Thomson in 1876.

According to Prof. Perrier's list, the Paris Museum also contains an undescribed species of *Pentacrinus*, viz. *P. asterius*, Miller; or is it possible that this is the original *Pentacrinus* which was described by Guettard, and was named *Isis asteria* by Linnæus, *Pentacrinus caput-medusæ* by Miller, and has been finally described as *Pentacrinus asterius*, Linn., sp.?

Another instance of the superficial manner in which Prof. Perrier has examined the work which he is supposed to be criticizing is afforded by the first line of the following statement*:—"Les *Pentacrinus* et *Metacrinus* ne diffèrent d'ailleurs que par le nombre des pièces calcaires (*pièces radiales*) qui se disposent en file pour soutenir les cinq premières paires de bras, et peut-être n'y avait il pas nécessité absolue de créer pour cela deux noms de genres distincts." The genus *Metacrinus* was suggested by Sir Wyville Thomson; but no other generic name has been established, as hinted by Prof. Perrier, on account of the difference of this type from that of *Pentacrinus* proper, which dates back to the time of Miller, as Prof. Perrier knows. It is true that in my preliminary report upon the 'Blake' Crinoids † I mentioned the number of radials as a difference between *Metacrinus* and *Pentacrinus*, because it is the character by which the two types can be distinguished at a glance; but I likewise stated that the radials of *Metacrinus* bear pinnules, which is not the case in *Pentacrinus*. If Prof. Perrier will take the trouble to refer to pp. 339 and 340 of the 'Challenger' Report he will find that the two genera also differ in the characters of the stem, cirri, arms, basals, and disc. Nevertheless, with this statement and the figures illustrating it before him, he tells us that the only difference

* 'Revue Scientifique,' May 30, 1885, p. 691.

† Bull. Mus. Comp. Zoöl. vol. x. no. 4, p. 167.

between the two types is in the number of their radials. What would he think of the reviewer of his Report on the 'Blake' Starfishes who said that the only difference between his two genera *Hymenodiscus* and *Anthenoïdes* was that the latter had but five arms and the former twelve?

Prof. Perrier's investigations into the obscure and much-neglected subject of the physiology of the Crinoids have led him to attribute a hitherto unsuspected function to the syzygial unions which occur in certain portions of the skeleton. He tells us* :—" Il y a au niveau de ces sortes d'articulations immobiles qu'on appelle les syzygies, chez les Encrines, tout un système de cavités puissamment munies des muscles qui chassent évidemment l'eau dans la substance même du tissu imprégné de calcaire des bras ou la conduisent au dehors et l'expulsent par les trous qui sont répartis à égale distance sur le pourtour de la syzygie."

It is, I think, much to be regretted that Prof. Perrier should have departed so far from the nomenclature of Müller and his successors as to speak of a syzygy as a kind of immovable articulation. Müller† called it an "unbewegliche Nathverbindung;" and he distinguished between a "Nath" and a "Gelenk" in the anatomy of a Crinoid. He only used the latter term when the two articulated joints were capable of movement upon one another; and this distinction has been almost universally adopted by later writers upon the subject, so that the term "articulation immobile," which Prof. Perrier employs has a somewhat contradictory sound. In the next line we are told by Prof. Perrier that among the "Encrines," the term which he uses throughout the whole of this article for the Stalked Crinoids only, the two joints are separated by a system of cavities which open externally by a series of pores round the edge of the syzygy. Such being Prof. Perrier's statement, let us examine in detail the evidence upon which it is based. In the first place, as explained in the 'Challenger' Report ‡, there are no syzygies at all anywhere in the arms of *Bathycrinus*. The Crinoids of this type are consequently very far from possessing such an extensive communication between the internal cavity and the exterior as is supposed by Prof. Perrier's theory that they are really in the same physiological condition as the sponges. For the number of ciliated water-pores on the disc of *Bathycrinus* is extremely limited and by no means a "foule d'orifices;"

* 'Revue Scientifique,' May 30, 1885, p. 692, note.

† "Ueber den Bau des *Pentacrinus caput-medusæ*," Abhandl. d. k. Akad. d. Wiss. Berlin, 1843, p. 39 (of separate copy).

‡ Zool. Chall. Exp. part xxxii. pp. 9, 231-233.

while in the case of *Rhizocrinus* one has still more difficulty in accepting Prof. Perrier's theory. For there are only five water-pores, at any rate in *R. lofotensis*; and though there are syzygies on the arms, their outlines are not marked by anything like pores, as is the case in the *Comatulæ*. As Prof. Perrier has plenty of *Rhizocrinus*-material at his command it is a little surprising that he should have committed himself to a general statement of this kind, which is so far from being in accordance with the actual facts of the case. The absence of the striæ, which are so characteristic of the syzygial faces of the *Comatulæ*, on the corresponding faces of the arm-joints of *Rhizocrinus* was noted by Sars* ; and without striæ there can be no pores. This observation was confirmed in the 'Challenger' Report; and it was also pointed out that the closeness of the syzygial union is increased by there being a small pit in the hypozygal which receives a backward process on the lower surface of the epizygal†. It will puzzle Prof. Perrier to discover, even with what his colleague Mons. Koehler calls "the eye of faith," any appearance of pores round the outline of a syzygial union in *Rhizocrinus*. The condition of the two living genera of the Bourgueticrinidæ, therefore, is far from being such as is implied by Prof. Perrier's very general statement; and he will find some difficulty in reconciling it with his "simple and new" conception of the mode of nutrition of the Crinoids. Let us see how far his statement is applicable to other genera of "Encrines" or Stalked Crinoids. He has never seen the arms of *Hyocrinus*, but apparently takes for granted the presence of syzygial pores, such as he believes to exist in the *Comatulæ*. I have not been able to examine one of the syzygial faces in an arm-joint of this genus, but there is no external indication of the presence of any radiating markings such as occur in the *Comatulæ*. The lines of syzygial union are perfectly continuous and uninterrupted, as is well shown in the figures published by Sir Wyville Thomson in 1876 ‡ and reproduced in pl. vi. of the 'Challenger' Report.

Here, then, is a third "Encrine" to which Prof. Perrier's statement and theory do not apply; and he fares no better in the case of *Holopus*. If there are any syzygial unions in the skeleton of this type at all they only occur between the two outer radials, and it is extremely doubtful if such is the case. At any rate, however, the apparent lines of syzygial union have no indication of possible pores, as is the case in the

* 'Crinoïdes vivants,' p. 22.

† Zool. Chall. Exp. part xxxii. pp. 5, 254, pl. x. figs. 1, 6, 8, 17-19.

‡ Journ. Linn. Soc., Zool. vol. xvi. pp. 51, 52.

Comatulæ. Thus, then, the only two recent "Encrines" to which Prof. Perrier's very general statement is at all applicable are *Pentacrinus* and *Metacrinus*. These two genera have syzygial unions in the stem as well as in the arms; but the apposed syzygial faces at one of the nodes of the stem are as smooth as they can be, and altogether devoid of any such markings or sculpture as could give rise to the appearance of pores along their line of union*. The syzygial unions in the rays and arms, however, are sometimes of a slightly different character and present some approach to the condition of the syzygies in the arms of *Comatulæ*. Dr. Carpenter † has described how each syzygial face in the arm of *Antedon rosaceus* is "almost flat, except that it presents a series of slightly elevated ridges with alternating furrows, which radiate from the opening of the central canal towards the dorsal margin. . . . The two sets of ridges are applied to each other, leaving between them flattened passages that are formed by the correspondence of the furrows. . . . An examination of decalcified specimens shows that the canals are occupied by radial extensions of the ordinary sarcodic basis-substance. The peculiar arrangement of these suggests that, like the 'medullary rays' of an exogenous stem, they may serve to establish a communication between the 'medullary axis' of this basis-substance which occupies the central canal, and the 'cortical envelope' by which the surface of the segment is invested." The coeliac canal rests in a more or less defined furrow upon the upper or ventral surface of each arm-joint, the so-called ambulacral groove of the skeleton; and Prof. Perrier tells us ‡ that "au niveau des syzygies, la cavité cœliaque communique avec un système de cavités rayonnant autour du cordon nerveux, entourées de muscles et qui jouent évidemment un rôle important dans la nutrition de la partie solide des bras."

This statement contains much debatable matter. In the first place, one would certainly expect that the contents of these syzygial cavities would be in communication with the axial canal from which they radiate, rather than with the coeliac canal on the ventral surface of the joint; but in a very large number of *Comatulæ* belonging to the genera *Antedon*, *Actinometra*, and *Promachocrinus* the axial canal or radial

* Zool. Chall. Exp. part xxxii. pp. 4, 5, 13, pls. xxxi., xxxii., xxxvii., xlvi., &c.

† "Researches on the Structure, Physiology, and Development of *Antedon* (*Comatula*, Lamk.) *rosaceus*.—Part I.," Phil. Trans. 1866, pp. 720, 721.

‡ "Résumé de Recherches sur l'organogenie des *Comatules*," Zool. Anzeiger, viii. Jahrg. 1885, no. 194, p. 265.

centre of the syzygial cavities is separated from the cœliac canal, which Prof. Perrier regards as their functional centre of supply, by more than half the height of the arm-joint. This is not the case in *Antedon rosaceus*, the type chiefly studied by Prof. Perrier; for it has relatively low arm-joints with a deep ambulacral groove on their ventral surface, so that there is but a thin layer of limestone between the bottom of the cœliac canal and the axial canal from which the syzygial cavities radiate. But if Prof. Perrier had had a more extensive acquaintance with the different types of arm-joint which occur in the *Comatulæ* and with the variations in the sculpture on their syzygial faces, I cannot but think that he would have hesitated before making the statement which has been quoted above.

It will be seen that he agrees with Dr. Carpenter in regarding these radiating syzygial furrows as nutritive in function, though he believes them to be filled with water from the cœliac canal, rather than with the sarcodic basis-substance of the skeleton, which would maintain communication between the internal and external tissues of the arm-joint, the latter often reaching a considerable thickness. The origin of these radiating canals in the central canal of the arm-joints which lodges the neuro-vascular axial cord certainly agrees better with the latter theory than with that of Prof. Perrier. It may be noted, too, that in his first account* of these cavities in the *Comatulæ*, he said not a word about their communicating with the exterior, as they sometimes seem to do in a dried arm of *Comatula*, or in a fragment which has been boiled in potash. He now tells us, however, that in the Stalked Crinoids (*Encrines*) these radiating cavities are not only present at the syzygies, but that they communicate with the exterior by pores placed at equal distances round the outline of the syzygy. Can he name a single Stalked Crinoid in which the syzygial faces are separated by radiating passages as in the *Comatulæ* and there are pores round the outline of the syzygies? *Bathyrinus* has no syzygies at all; and there are no pores or anything resembling them in *Rhizocrinus*, *Hyocrinus*, or *Holopus*. Prof. Perrier has never seen a *Metacrinus*, or he would scarcely have doubted its distinctness from *Pentacrinus*; and, unless I am greatly mistaken, he has never had an arm-fragment of the former genus from which to cut a section through a syzygial union. The only possible type, therefore, which could have furnished him with the evidence on which he bases his statements respecting the

* Zool. Anzeiger, 1885, p. 265.

Stalked Crinoids is *Pentacrinus* itself. Can he name a single recent species of this genus in which the syzygial faces are marked by elevated ridges and furrows radiating from the central canal as in the *Comatulæ*? In by far the greater number of cases the joints are perfectly plain, without any indications of sculpture at all*; but there is sometimes a slight trace of striation round the margins of apposed syzygial surfaces. Exactly the same thing often occurs on the apposed surfaces of the basals and radials respectively, and on the lateral surfaces of the radials where they are closely united by suture. Sometimes, indeed, there is a faint indication, over part of the syzygial face, of a radial striation which extends inwards towards the central canal but dies away before reaching it, and is not due to the presence of elevated ridges, as in the *Comatulæ*. The best instance of this which I know is on the apposed syzygial faces of the radials of a *Pentacrinus asterius* which were figured by Sir Wyville Thomson in the 'Challenger' Report †; but his figure of the "pourtour de la syzygie" on the dorsal aspect of the ray shows it to be absolutely devoid of all trace of pores, as is really the case. I have seen many other indications of radial striation, both in this and in other species of *Pentacrinidæ*; but they are merely superficial markings on the joint-faces, and are altogether different from the well-defined radiating ridges on the syzygial faces of a *Comatula* arm-joint, which can be stripped off entire when the syzygy is split open after decalcification. It is, of course, possible that Prof. Perrier may have obtained a section through a syzygy in a *Pentacrinus*-arm with better-defined radiating ridges and intervening furrows than any which I have seen in this genus; but I doubt it. The dredgings of the 'Talisman' yielded several specimens of *Pentacrinus Wyville-Thomsoni*; and if Prof. Perrier has not cut sections through a syzygy of this species, it would have been better for him to have done so before making a general statement respecting the syzygies of Stalked Crinoids which harmonizes so admirably with his previously expressed views. I have several sections through the largest syzygy in this species, viz. that between the second and third radials; and there is absolutely no trace either of the radiating cavities or of the powerful muscles which Prof. Perrier describes in the "Encrines." I can say the same of the arm-syzygies in *Pentacrinus decorus*; and if the smooth appearance of the syzygial faces is any guide, there is not a single recent mem-

* Zool. Chall. Exp. part xxxii. pp. 4, 254, pls. xxvi. & xxxvii.

† Pl. xii. figs. 17, 18, 21.

ber of the Pentacrinidæ, any more than there is of any other family of Stalked Crinoids, with radiating cavities at its syzygies as described by Prof. Perrier. Even as regards the *Comatulæ*, which do have more or less appearance of external pores at their syzygies, I cannot accept Prof. Perrier's assertion as at all consistent with the facts of the case. I do not deny that pores appear at the syzygies on arms which have been boiled in potash, as was figured by Dr. Carpenter in *Antedon rosaceus**; but there is a layer of perisome † outside the skeleton which is removed by this treatment, so that the pores appear far more distinctly than they do in a dry arm, and still more so than in a fresh or spirit-specimen. This layer of perisome is very well shown in the terminal parts of arms which have been stained with picocarmine and mounted in dammar; and the syzygial pores are then seen to be covered by it. The sections which I have made in three planes through the arms of many species of *Comatula* have given me every reason to believe that the pores of the skeleton do not open to the exterior through this layer of perisome (which is often much thicker than in *Antedon rosaceus*) as Prof. Perrier's theory requires; while I much doubt whether the so-called powerful muscles are anything more than the closely set fibres which form the organic basis of the elevated radiating ridges on the syzygial faces. It is certainly very remarkable that the positions assigned to these muscles by Prof. Perrier are exactly those where the calcareous tissue is densest, on the syzygial faces of fossil arm-joints. I have explained elsewhere ‡ how the organic basis of the pieces of the skeleton becomes much more close and compact near those surfaces which are in contact with other joints; and I believe this to be preeminently the case at the syzygies, though the apposed faces are not so perfectly united as in the case of the basals and radials, for the syzygial unions are severed with great ease. If Prof. Perrier really does believe that water is driven out from pores at the arm-syzygies of *Antedon rosaceus*, he can prove it in a very simple way. If he will "pith" the creature by removing its chambered organ it will lie still in the water; and the action of the powerful muscles expelling water from the syzygial pores would surely cause such a disturbance in the surrounding medium as would

* Phil. Trans. 1866, pl. xxxvi.

† The "cortical envelope" of Dr. Carpenter.

‡ "On the Genus *Actinometra*, Müll., with a Morphological Account of a new Species from the Philippine Islands," Trans. Linn. Soc. 1879, 2nd ser., Zool. vol. ii. pp. 55-57.

prove his theory incontestably. Has he performed this experiment or any one which would give the same results? Even then, however, his theory does not hold good for the Stalked Crinoids, none of which have any radiating cavities or pores at their syzygies, while these unions are altogether absent in *Bathycrinus*. His assertion that water is expelled from the coeliac canals of the arms through pores on the "pourtour" of the syzygies would thus appear to be a somewhat hasty generalization from the supposed condition of the *Comatule*. It is essential, however, to his conception of a Crinoid as a kind of sponge with incurrent and excurrent openings for the circulation of water. The former are provided for by the ciliated water-pores on the disc; but where are the latter in *Holopus*, *Hyocrinus*, *Bathycrinus*, *Rhizocrinus*, and, I will also add, in the Pentacrinidæ?

Professor Perrier's brief notice of the 'Challenger' Report contains the following passage *:—"Poussé par on ne sait quelle prévention assez mal dissimulée contre ce qu'il appelle un peu dédaigneusement 'l'école française,' M. Herbert Carpenter, dont les études ont été terminées à l'Université de Würzburg (*sic*), s'est, en bon camarade, jeté tête baissée à la suite du zoologiste allemand qui a le plus habilement étudié les Crinoïdes. Il affirme en avoir confirmé presque tous les résultats dont beaucoup sont cependant erronés, et il ne se sépare guère de son guide que pour défendre les opinions, d'ailleurs exactes, de son père relativement au système nerveux."

The last sentence contains a statement which falls very considerably short of the truth. Not only do I disagree with the published views of my old friend Prof. Ludwig respecting the nervous system of Crinoids, but I have given a different account of the basals of *Rhizocrinus* from that which he put forward; and, in common with Mr. Sladen †, I dissent altogether from the theory which he has published concerning the relations of the Crinoid calyx in the Urchins and Starfishes ‡. I differ from him and from other German writers, Studer and Hörnes §, upon this purely theoretical point as

* 'Revue Scientifique,' May 30, 1885, p. 693.

† "On the Homologies of the primary Larval Plates in the Test of Brachiata Echinoderms," Quart. Journ. Micr. Sci. n. s. vol. xxiv. 1884, pp. 35-37.

‡ *Ibid.* vol. xx. 1880, pp. 322-329; and "Notes on Echinoderm Morphology.—No. V. On the Homologies of the Apical System, with some Remarks upon the Blood-vessels," *Ibid.* vol. xxii. 1882, pp. 376-386.

§ "On the Apical System of Ophiurids," *Ibid.* vol. xxiv. 1884, pp. 15-18; and Zool. Chall. Exp. part xxxii. pp. 392-400.

strongly as I do from the French authors, Messrs. Perrier, Koehler, and Apostolidès, respecting the supposed communication with the exterior of the so-called blood-vascular system in Urchins and Ophiurids, through the pore-canals of the madreporite. It is on this last point, which deals with fact and not with theory, that, like Ludwig, I am at variance with what I ventured three years ago to call "the French school." My reasons for the "prévention" referred to by Prof. Perrier are twofold.

In the first place, I do not believe many of their statements of fact to be correct, as I distrust the nature of the evidence upon which these are based; and, secondly, there is far too strong a tendency, especially in the case of Professor Perrier, to make a sweeping generalization upon data which are either altogether inadequate or even absolutely incorrect. An excellent instance of the latter kind is afforded by Prof. Perrier's statement respecting the presence of radiating cavities at the syzygies of the Stalked Crinoids, which I have discussed above.

The greater part of his publications upon the morphology of the Crinoids have been limited to what he himself describes * as "quelques fragments isolés" of his results. Some of his earlier statements have been profoundly modified in later communications, while others have been tacitly withdrawn. Among the latter, for example, is the expression of his conviction that no one will ever find the cœliac canal of a Crinoid †, although he now tells us that it communicates with the exterior through pores at the syzygies of the arms. After having once asserted that the cirrus-stumps of a Pentacrinoid larva alternate with those of the arms ‡, in spite of the evidence to the contrary in the descriptions and figures of Dr. Carpenter § and M. Sars ||, Prof. Perrier now tells us ¶ that the cirri and the arms are "superposed," a fact that has been known for the last twenty years. Then, again, Prof. Perrier ** claims to have "démontré" that the inter-

* Zool. Anzeiger, 1885, p. 267.

† "Recherches sur l'Anatomie et la Régénération des Bras de la *Comatula rosacea*," Arch. de Zool. Expér. et Génér. t. ii. 1873, pp. 48, 49, 73.

‡ "Sur la développement des *Comatules*," Comptes Rendus, tom. xxviii. 1884, p. 446.

§ Phil. Trans. 1866, pls. xl., xli.

|| 'Crinoïdes vivants,' tab. v. p. 53.

¶ Zool. Anzeiger, 1885, p. 264.

** "Sur une Astérie des grandes profondeurs de l'Atlantique, pourvue d'un pédoncule dorsal," Comptes Rendus, t. xcv. 1882, p. 1381.

radial abactinal plates of the young *Brisinga* eventually become the odontophores; and upon this supposition he based a generalization concerning the whole of the Asterids. As a matter of fact, however, he was merely repeating a statement made some time previously, but never satisfactorily proved; while its accuracy has since been questioned by Sladen*, who has also proved beyond all doubt that, whatever be the case in *Brisinga*, Prof. Perrier is utterly at fault with regard to the fate of the interradian abactinal plates in other Starfishes.

According to Prof. Perrier, it has been demonstrated by himself, together with Koehler and Apostolidès, that the blood-vascular system of Urchins and Ophiurids communicates directly with the exterior through the madreporite. But I have pointed out elsewhere† that no valid proof of this statement has ever been furnished to morphologists, except an account of the results of injections. I may be peculiar, but I do not believe in the injection method as a means of settling intricate anatomical questions. Sometimes, as Ludwig has shown in the case of Greeff and Hoffmann, it proves, or rather appears to prove, far too much; while in other cases it gives altogether insufficient results. Some years ago, in consequence of unsuccessful injections, Prof. Perrier was led to deny the existence of what is generally known as the blood-vascular ring of *Echinus*, and of a vessel which had been supposed to connect it with the so-called heart or ovoid gland‡. His friend Mons. Koehler, however, was able to demonstrate the presence of these organs without difficulty; and he confirmed the results of his injections by the section-method§. But neither Koehler, Perrier, nor Apostolidès has figured a single section which shows how the ovoid gland of any Urchin or Ophiurid communicates with the exterior; though their injections have caused them to speak of it as a demonstrated truth about which there can be no doubt whatever||. Ludwig's careful sections and dissections of the madreporite of a Starfish, however, have led him to the conclusion, which his

* Quart. Journ. Micr. Sci. n. s. vol. xxiv. pp. 39-41.

† "Notes on Echinoderm Morphology.—No. VI.," *Ibid.* vol. xxiii. pp. 597-609; No. IX. *Ibid.* Supplement, 1885, pp. 13-18 (of separate copy).

‡ "Sur l'Appareil circulatoire des Oursins," *Comptes Rendus*, Nov. 16, 1874; and "Recherches sur l'Appareil circulatoire des Oursins," *Arch. de Zool. Exp. et Gén.* t. iv. 1875, p. 613.

§ "Recherches sur les Echinides des Côtes de Provence," *Ann. du Mus. d'Hist. Nat. de Marseille, Zoologie, Mém.* no. 3. pp. 65-70.

|| R. Koehler, "Quelques mots sur les relations du système circulatoire chez les Echinides," *Zool. Anzeiger, Jahrg.* viii. 1885, p. 81.

figures fully bear out, that the pore-canals of the madreporite lead into the water-vascular apparatus only, and have absolutely no connexion with the blood-vascular system*.

These statements have never been contradicted by Professor Perrier, who has nowhere described any such communication between the water-vascular and blood-vascular systems of a Starfish as he believes to exist in Urchins and Crinoids.

But all the same, he places the Starfishes, together with the other Echinoderms, in the same division of the Metazoa as the Polypes and Sponges. The bodies of the animals composing this group, which he calls "Zoophytes," are traversed by a set of irrigating canals †—"Il contient de même, non pas de sang, mais de l'eau qu'il puise incessamment au dehors et se substitue tout à la fois à l'appareil circulatoire et à l'appareil respiratoire des animaux mobiles, à la symétrie bilaterale, avec lesquels il n'a aucun rapport morphologique. On doit remarquer que, chez les échinodermes, il dérive au moins indirectement de la cavité digestive primitive."

This conception of the mode of nutrition of Echinoderms is well described by Prof. Perrier as both "simple and new;" but he can scarcely expect it to be adopted by other naturalists until he can demonstrate to their satisfaction the fundamental unity of the double vascular system and its communication with the exterior not only in Echini, Ophiurids, and Crinoids, but also in Starfishes and Holothurians, about which groups he has given us no positive information at all.

My own observations have led me to believe that the statements which he has permitted himself to make concerning the presence of excurrent openings in the arms of Stalked Crinoids are absolutely without any foundation of anatomical fact. But they harmonize with his theories of Crinoid morphology in a way which leaves nothing to be desired for completeness; and I have a strong suspicion that some of his other assertions respecting the vascular system of the Echinoderms are equally untrustworthy, as, indeed, has been already proved by Koehler. Other investigators are at work upon the subject, and we may hope to hear a good deal about it before many months are past.

* "Beiträge zur Anatomie der Asteriden," *Zeitschr. f. wiss. Zool.* Bd. xxx. 1878, p. 104.

† 'Revue Scientifique,' May 30, 1885, p. 692.